Remarks

Applicants thank the Examiner for the careful examination of this application and the clear explanation of the rejections.

The specification amendment corrected the SUMMARY OF THE INVENTION as requested by the examiner. This change introduced no new material.

Claim 1 defines a method for removing photoresist from a semiconductor wafer containing oxygen sensitive material. The method comprises using a downstream plasma comprising hydrogen or deuterium and substantially no oxidizing component.

A first layer is formed on a semiconductor wafer.

A photoresist layer is formed on the first layer.

The first layer is patterned and the photoresist layer is removed using the downstream plasma comprising hydrogen and deuterium with substantially no oxidizing component.

The term downstream plasma is a term of art that is described in the attached document on plasma etching which was taken from the book Plasma Etching edited by Dennis M. Manos and Daniel L. Flamm. The document is included in the accompanying information disclosure statement.

As outlined in the document, it is well established that in a downstream plasma the particles which are incident on the surface

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of the wafer are neutral particles. (pages 68, 69 and 70). Thus what is claimed in claim 1 is a plasma removing process where excited electronic state neutral atoms or molecules of hydrogen and/or deuterium are incident on the surface of the wafer to remove the photoresist. It is also claimed in claim 1 that this process is performed with substantially no oxidizing component. As described on page 9, lines 26-29, and page 10, lines 1-6, this requires that the particles impinging on the wafer surface contain substantially no oxygen and no charged hydrogen species.

The Zhao et al. patent (5,660,682) discloses a method for removing polymer 20A and 20B and an oxide layer 22 shown in Figure 1. As taught by Zhao et al., these polymers 20A and 20B can be removed by energizing hydrogen and argon to create positive argon and hydrogen ions. (column 3, lines 39-40). Zhao et al. further teaches that the ions may be accelerated toward the integrated circuit by a negative DC bias of between about 10 volts and about 600 volts, and most preferably about 400 volts (column 3, lines 51-54). Zhao et al. further teaches that these hydrogen ions are reactive with the material 20A, 20B and 22 (column 3, line 65).

The Hause et al. patent (6,013,574) describes a process for removing remaining photoresist using a downstream plasma process containing a substantial oxygen component. In particular, gas flow rates of 500 sccm of oxygen (O_2) and 3000 sccm of forming gas are disclosed (column 5, line 40-44). The composition of forming gas is further defined in the disclosure as a mixture of 96% nitrogen and 4% hydrogen (column 5, line 35-38). There is therefore more than four times as much oxygen flowing compared to hydrogen. Referring to Figure 10 of the disclosure, data is presented for a

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O_2 + Low Flow Rate forming gas process and an O_2 + High Flow Rate Forming Gas process.

As described in the patent of Zhao et al. (5,660,682), charged hydrogen species are used to remove polymer from the surface of the wafer. Charged hydrogen will act to physically displace surface atoms. This is differentiated from the instant disclosure and claim 1 where neutral hydrogen is claimed as the reactive species. Neutral hydrogen will not act physically to bombard and displace surface contaminants but will act as a chemical reducing agent.

The physical and chemical properties of charged hydrogen and neutral hydrogen are vastly different. It is therefore not obvious that either species would have similar chemical behavior with regard to a third substance. This is true for charged and neutral hydrogen just as it would be true for any two species having vastly different chemical and physical properties.

Hause et al. teaches that a substantial component of the gas mixture is oxygen, and that oxygen is necessary to achieve removal of the photoresist. It is not obvious that removal of oxygen from the gas mixture containing in case 1 of Hause et al. (Column 8, lines 4-5) 90.9% O_2, 8.7% N_2 and 0.36% H_2 and in case 2 (Column 8, lines 7-8) 14.3% O_2, 82.3% N_2 and 3.4% H_2 would result in a process capable of removing substantial polymer residue or photoresist.

It is well known in the art that an oxygen based plasma will remove photoresist. Hause et al. teaches using a plasma consisting of mostly oxygen and a small amount of hydrogen. Hause et al.

specifically teaches that, "[f]orming gas is advantageously employed during the etching removal of the remaining portion of photoresist layer 18 in order to remove the etch byproduct polymer layer 23 formed over areas of the upper surface of antireflective layer 16 exposed at the bottoms of the vias." (Column 5, lines 56-60). Hause et al. in the above paragraph carefully differentiates photoresist from the etch byproduct polymer layer and states that hydrogen is included to remove the etch byproduct polymer. Hause et al. therefore teaches that oxygen will remove the photoresist and hydrogen will remove the etch byproduct polymer. As described in the Hause et al. disclosure and well known in the art, photoresist and the etch byproduct polymer are different materials with different properties. Hause et al. does not teach or suggest that hydrogen can be used to remove the photoresist. Hause et al. clearly teaches that an oxygen plasma will remove the photoresist. In fact because oxygen and hydrogen represent oxidizing and reducing reactants, Hause et al teaches, in the most general way, that an oxidizing reactant will remove photoresist and a reducing reactant will remove the etch byproduct. Hause et al. does not teach or suggest that hydrogen can be used to remove the photoresist. There is nothing in the Hause et al patent that would deem this process obvious under the criteria required for 35 U.S.C. 103(a).

Amended claim 1 distinguishes over Zhao et al. and the Hause et al. patents by requiring that the photoresist layer be removed using a hydrogen or deuterium downstream plasma containing substantially no oxidizing component. Each independent claim of the amended claims contain this limitation. Thus each independent distinguishes over the Zhao et al. and the Hause et al. patents.

Since the dependent claims all depend on the independent claims then the dependent claims also distinguish over Zhao et al. and Hause et al.

The application is in allowable form and the claims distinguish over the cited references. Applicants respectfully request reconsideration or further examination.

Respectfully submitted,

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